

The Effects of School Facility Quality on Teacher Retention in Urban School Districts

National Clearinghouse for Educational Facilities

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Abstract

The attrition of both new and experienced teachers is a great challenge for schools and school administrators throughout the United States, particularly in large urban districts. Because of the importance of this issue, there is a large empirical literature that investigates why teachers quit and how they might be better induced to stay. Here we build upon this literature by suggesting another important factor: the quality of school facilities. We investigate the importance of facility quality using data from a survey of K-12 teachers in Washington, D.C. We find in our sample that facility quality is an important predictor of the decision of teachers to leave their current position.

Introduction

A major component of the No Child Left Behind Act (NCLB) mandates that all teachers in core subjects be "highly qualified" by 2005-6. Leaving aside the debate over the definition of "highly qualified," few would challenge the assertion that the nation needs to attract the best possible teachers to the profession. However, as school administrators and education researchers have long known, hiring bright new teachers is only part of the problem—the attrition of both new and experienced teachers is as great a challenge for schools and school systems.

The importance of the issue of teacher retention has led to a substantial literature on the subject in the field of education research. In this paper, we make two contributions to this literature. First, we argue that the quality of school facilities is an important factor in the decision making of individual teachers. Although, as we note below, the importance of facility quality has been studied only in the context of teacher retention in

developing countries, we believe that it is also relevant in the United States, particularly in large, urban school districts where facility quality is often poor.

Second, we test our argument empirically by comparing the effect of facilities, *ceteris paribus*, to other factors identified in the literature that affect teacher retention. To do this, we use data from a survey of teachers in Washington, D.C. conducted in the Spring of 2002. We find that, even when controlling for a host of other factors, the quality of school facilities is an important predictor of the retention/attrition decision.

We begin with a brief review of the relevant literature on teacher retention. After this, we discuss why facilities are important. We then present our empirical evidence and conclude with some implications of this research for educators and policy makers.

Why Do Teachers Quit?

Many analysts argue that current school staffing problems are caused as much by teacher attrition as by the failure to attract new teachers. Indeed, research has shown that approximately one-quarter of all beginning teachers leave teaching within four years (Benner 2000; Rowan et al. 2002). In general, teachers list family or personal reasons, such as pregnancy, the demands of child rearing, and health problems as reasons for leaving the profession. Job dissatisfaction, primarily due to poor salary, poor administrative support, and student discipline problems, is also among the most frequent reasons teachers give for leaving the profession (Tye and O'Brien 2002; Ingwersoll 2001; MacDonald 1999). In addition, some qualitative research indicates that more general factors, including government policies, portrayal of teachers in the mass media, and community attitudes, also influence teachers' general esteem and status in society, which features largely in their professional commitment and morale.

Because there are so many possible factors identified in the literature that influence retention, we organize our review of the literature below into factors related to teachers, schools, and communities.

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Teacher Factors

Relatively low wages (especially considering the number of years of higher education that the average, state-certified teacher has completed) are frequently cited as a cause of teacher attrition. For example, in a 2002 survey, teachers in California who are considering leaving the profession rank "salary considerations" as the most important factor driving their decision (Tye and O'Brien 2002). Similarly, Gritz and Theobold (1996) find that compensation is the most important influence on the decision to remain in the profession for male teachers and experienced female teachers.

Using the National Longitudinal Study of the High School Class of 1972 (NLS-72), Stinebrickner (2001) develops a more complex model of the effect of wages on attrition in the context of the larger labor market. According to this research, graduate education and teaching experience are significant determinants of teaching salary, which, in turn, has a positive effect on teacher retention. While men and women receive similar wages in teaching, men have much greater opportunities for higher-paying non-teaching jobs. Individuals with higher SAT math scores have notable wage advantage in non-teaching jobs but lose it if they choose to teach. In turn, the relative attractiveness of non-teaching jobs may be the primary cause of teacher attrition for the academically gifted teachers (as measured by SAT math scores) and male teachers, but not necessarily for the other teachers. This is supported by the fact that most teachers who quit teaching quit the workforce altogether (also see Murnane and Olsen 1989, 1990). From a comparative perspective, Dolton and Klaauw (1995) report that teacher attrition rate in the U.K. is also driven by poor salary relative to non-teaching jobs.

The idealism of teachers also matters. Perhaps counter-intuitively, there are higher attrition rates among teachers who have a strong "service ethic" (measured by the importance of service to society for individual teachers relative to other motivations to teach). Miech and Elder (1996) find that evidence of this effect is still strong after controlling for variables such as family SES background, occupational commitment, salary, marital status, number of children, public-private schools, race, employment history, and academic ability. The authors offer various explanations for the high attrition rates among idealists, perhaps the most compelling one suggests that school environment in general provides less than sufficient guidance on the goals, means, and evaluation of their work and people who are highly service-motivated get easily frustrated with this uncertainty.

There are debates about the effects of teacher preparation on recruitment and retention. Teachers who graduate from traditional university-based programs have lower attrition rates than teachers with other, non-traditional forms of preparation (Harris, Camp, and Adkison 2003). A large percentage of new teachers also report that the teacher preparation programs they went through did not provide enough help for them to cope with their first-year experience, which intensifies the need for proper mentoring, professional development, and administrative support in their working environment (Tapper 1995).

School Factors

Hanushek, Kain and Rivkin (forthcoming) argue that, while clearly important, teacher salaries are not all that matter—they show that teacher preferences across a range of job and school conditions may be just as important as salary in the retention decision. According to their study, "teachers might be willing to take lower salaries in exchange for better working conditions" (also see Antos and Rosen 1975; Chambers 1977; Murnane 1981; Baugh and Stone 1982; and Hanushek and Lague 2000).

Rosenholtz and Simpson (1990) offer a detailed analysis of how organizational factors contribute to teacher's commitment to the workplace. Their evidence shows that school management of student behavior and the burden of non-teaching obligations affect new teachers' commitment much more than it does experienced teachers (see also Hargreaves 1994; Macdonald 1995). On the other hand, experienced teachers appear to be more concerned with the discretion and autonomy they have in their schools. Other important predictors of teachers' commitment include: performance efficacy—a teacher's perception of how his or her teaching, in the particular school context, will affect students' learning; psychic rewards—a variable which, like performance efficacy, is generated both from a teacher's own qualification and from school's organizational quality that allows free flow of supportive/constructive feedback; and learning opportunities—including mentoring for new teachers and other plans for professional development. Rosenholtz and Simpson (1990) further find that teachers' commitment to the workplace, measured by their disaffection, absenteeism, and defection, is highly correlated with turnover.

The lack of resources in a school also contributes to teacher job dissatisfaction, which then can lead to attrition. In interviews with public school teachers in New York City, a large percentage of new teachers said they did not have access to adequate basic supplies. Most

teachers had to use their own money to equip their classroom. Of the teachers interviewed, 26 percent report spending \$300 to \$1000 of their own funds on classroom supplies over the year, 14 percent spent \$100 to \$200, and 12 percent \$50 to \$75. In addition to this, most teachers report that they do not have enough textbooks or that the textbooks they do have are in poor condition. In turn, photocopying materials becomes a considerable part of their tasks, but school copy machines are frequently broken, and teachers have to rely on family, friends, or other private resources to reproduce the materials (Tapper 1995).

Ironically, NCLB itself may be working against the improvement of the nation's stock of quality teachers. In Tye and O'Brien's (2002) survey of teachers, the top-ranked reason for quitting teaching among those who had already left the profession is "accountability" and the increasing use of high-stakes, standards-based testing with the associated "drill and kill" curricula that often come with it (see also Darling-Hammond and Sykes 2003).

Community Factors

Erratic government education policies (such as those relating to teacher licensing and certification) and unresponsive education bureaucracies are a significant source of frustration for new teachers. Tapper (1995), for example, reports that a majority of the teachers interviewed "spoke at length and with anger" about the confusion of policies, the lack of clear and accurate information, and repetitive and costly licensure or certification procedures. Some also expressed worries of staying in the teaching profession because of government budget-cutting.

Another important factor in the retention decision may be the social status of the teaching profession in the broader community (Tye and O'Brien 2002). In interviews with rural Australian teachers, for example, a primary source of their anxiety about the profession was dealing with a misinformed community. Teachers report that they have to repeatedly battle public stereotypes that their professional day begins at 9:00 am and ends at 3:00 pm, that they enjoy high salaries and numerous vacations, and that their jobs are easier than most other professions. All the teachers in the sample report being alienated from people in non-teaching professions. Overall, teachers find a professional paradox-their community has great expectations from education, but teachers are accorded low social status and held in low esteem (Jones 2001).

In the United States this problem may again be exacerbated by the same legislation that currently mandates high quality teachers. As several researchers have suggested, the provisions in NCLB that brand schools as failing if they do not meet "adequate yearly progress," by stigmatizing them with the "in need of improvement" or failing label, may perversely increase the difficulty of hiring and retaining good teachers in the schools where they are needed most (Darling-Hammond and Sykes 2003; Figlio 2001).

Do School Facilities Matter?

Myriad factors clearly affect teacher retention, but most teaching takes place in a specific physical location (a school building) and the quality of that location can affect the ability of teachers to teach, teacher morale, and the very health and safety of teachers. Despite the importance of the condition of school buildings, serious deficiencies have been well documented, particularly in large, urban school districts (see for example, GAO 1995). Moreover, since school buildings in the United States are, on average, over forty years old-just the time when rapid deterioration often begins-we should expect problems with school facilities to worsen.

Many factors contribute to the quality of the school building and, in turn, affect the quality of teacher life and educational outcomes. For example, poor indoor air quality (IAQ) is widespread and many schools suffer from "sick building syndrome" (see, for example, EPA 2000), which in turn increases student absenteeism and reduces student performance (see EPA 2000; Kennedy 2001; Leach 1997; Smedje and Norback 1999; Rosen and Richardson 1999). Since current student-focused asthma studies show that students lose considerable school time because of the poor conditions of schools, it is not surprising to find that poor IAQ also affects teachers' health. In our study, fully two-thirds of Washington teachers surveyed reported poor indoor air quality in their school.

Another area in which research has linked school facilities to teacher performance is thermal comfort. Lowe (1990) found that the best teachers in the country (winners of State Teachers of the Year awards) emphasized their ability to control classroom temperature as central to the performance of both teachers and students. Lackney (1999) showed that teachers believe thermal comfort affects both teaching quality and student achievement. Corcoran et al. (1988) focused on how the physical condition of school facilities, including thermal factors, affects teacher morale and effectiveness (also see Heschong Mahone Group 2002).

Classroom lighting plays a particularly critical role in student performance (Phillips 1997). Jago and Tanner (1999) cite results of seventeen studies from the mid-1930s to 1997. The consensus of these studies is that appropriate lighting improves test scores, reduces off-task behavior, and plays a significant role in the achievement of students. Over 21% of the Washington DC teachers that responded to our study reported that the lighting in their school was inadequate.

Recently there has been renewed interest in increasing natural daylight in school buildings. Until the 1950s, natural light was the predominant means of illuminating most school spaces, but as electric power costs declined, so too did the amount of daylighting utilized in schools. But recent changes, including energy efficient windows and skylights and a renewed recognition of the positive psychological and physiological effects of daylighting, have heightened interest in increasing natural daylight in schools (Benya 2001).

Lemasters' (1997) synthesis of 53 studies pertaining to school facilities, student achievement, and student behavior reports that daylight fosters higher student achievement. The study by the Heschong Mahone Group, covering more than 2000 classrooms in three school districts, is perhaps the most cited evidence about the effects of daylight. The study indicated that students with the most classroom daylight progressed 20% faster in one year on math tests and 26% faster on reading tests than those students who learned in environments that received the least amount of natural light (Heschong Mahone Group 1999; also see Plympton, Conway and Epstein 2000). Despite the importance of natural lighting for learning and achievement, over 20% of the teachers in Washington DC reported that they can't see through the windows in their classroom.

The final facility condition that we note here pertains to noise levels. The research linking acoustics to learning is consistent and convincing: good acoustics are fundamental to good academic performance. Earthman and Lemasters (1997) report three key findings: that higher student achievement is associated with schools that have less external noise, that outside noise causes increased student dissatisfaction with their classrooms, and that excessive noise causes stress in students (1997:18; also see Crandell, Smaldino, and Flexer 1995; Nabelek and Nabelek 1994; ASHA 1995; Crandell 1991; Crandell and Bess 1986; and Evans and Maxwell 1999). Teachers also attach importance to noise levels in classrooms and schools. Lackney (1999) found that teachers believe that noise impairs academic

performance. Indeed, it appears that external noise causes more discomfort and lowered efficiency for teachers than for students (Lucas 1981). Again schools in our study are failing to provide this basic input to education: Almost 70% of Washington teachers report that their classrooms and hallways are so noisy that it affects their ability to teach.

While a literature linking school facilities to learning outcomes and teacher morale is developing, there is little research on the effects of school facility quality on teacher retention decisions. What literature there is limited to research on the education systems of developing nations, where the poor condition of classrooms, lighting, and furniture have been linked to attrition (Chapman 1994; Kemmerer 1990). The possibility of a direct link between school facility and teacher turnover, however, has not been well-explored in this literature. It is this link that we explore next.

A Multivariate Model

To test the extent to which facilities quality affects teacher retention, we use data from the survey of teachers in Washington, D.C. noted above. Our dependent variable is the dichotomous response a question that asked teachers: "Do you plan to remain another year in your current school?" Thus we are operationally defining attrition more narrowly than a departure from the profession-however, retaining teachers in any given school is essential to its functioning and ultimately to meeting the mandate of NCLB.

The review of the literature above identified many potential factors associated with teacher retention. Therefore, in order to get an accurate estimate of the effect of school facilities on teacher retention decisions, we must control for other factors in any empirical model. Accordingly, we estimate a maximum-likelihood probit regression of the individual teacher's reported decision to stay (coded 1 if yes) on a set of covariates reflecting a host of factors that may drive the retention decision.

Our main variable of interest is the condition of the school facility, reflected by the grade that the teacher assigns to their school facilities (on the familiar A-F scale, which we treat here as a continuous measure). In addition, we include a series of measures that reflect individual, school and community factors that can affect the propensity to leave. These include such individual measures as the respondents' age (actually measured categorically but assumed to be continuous here) and their age squared (to account for a likely nonlinear

effect); whether the respondent is female; whether they are "very dissatisfied" with their present salary; the number of years spent at their present school; whether they hold D.C. teaching certification; and dichotomous variables for self-reported race as white or other (black is the excluded, modal category).

To reflect school and community conditions, we measure the level of satisfaction with their central district leadership and management; the level of involvement of parents and the local community; whether community and parents are "very important;" and whether they would be willing to be involved planning improvements in their school's facilities.

Table 1: Factors that May Affect Retention

	Sample Mean, Percentage, or Modal Category
Facilities Grade	1.98
Age (Categorical)	41-50
Female	75.3%
Very Dissatisfied with Pay	21.2%
Very Dissatisfied with Community	40.5%
Very Dissatisfied with Administration	26.2%
Years at Same School (Categorical)	4-10
Community Very Important	75.5%
Willing to Volunteer	50.3%
D.C. Certified	78.0%
White	18.7%
Other Race	7.2%

Number of Observations = 835

Table 1 summarizes the list above and reports the observed sample mean or proportion responding in the affirmative for the various covariates. After listwise deletion of missing values, the remaining sample size is 835. The results of the estimation of our model are presented in Table 2. We should note that because, in most cases, we received responses from several teachers in the same school, we estimate robust standard errors clustered on the reported D.C. school building number (White 1980, Rogers 1993).

As Table 2 shows, we find a statistically significant coefficient for the effect of facilities grade on the decision to stay. As the perceived quality of the school facilities improves, *ceteris paribus*, the probability of retention increases. We also find significant effects for teacher age, dissatisfaction with pay, dissatisfaction with the involvement of parents and the community, and for length of service at the present school. Overall, the model correctly predicts 83% of the observations, for a modest but measurable reduction in error of 6% over simply using the modal category to predict. In addition, based on a chi-squared test of the ratio of log-likelihoods, we can reject a constant-only model compared to the full model at $p < .01$.

Table 2: Results of the Model

	Coefficient (Standard Error)
Facilities Grade	.117 (.059)**
Age	.950 (.248)***
Age Squared	-.153 (.043)***
Female	.137 (.104)
Very Dissatisfied with Pay	-.319 (.110)***
Very Dissatisfied with Community	-.469 (.117)***
Very Dissatisfied with Administration	-.055 (.114)
Years at Same School	.094 (.055)*
Community Very Important	-.177 (.143)
Willing to Volunteer	.175 (.116)
D.C. Certified	-.025 (.120)
White	-.171 (.158)
Other Race	.035 (.226)
Constant	-.455 (.406)
Log-likelihood	-346.78
Percent Correctly Predicted	83%
Percent Reduction in Error	6%

*** $p < .01$; ** $p < .05$; * $p < .10$, two-tailed

Number of observations = 835

Coefficients are from prohibit regression of respondent's intention to remain at present school. Standard errors reported are robust standard errors (Huber-White) clustered on individual schools.

As is well known, due to the nonlinearity of the probit model, we cannot gauge the magnitudes or relative effects of the various factors on the retention decision simply by looking at the estimated coefficients (Liao 1994). Accordingly, we compute predicted probabilities using stochastic simulation (King, Tomz, and Wittenberg 2000; Tomz, Wittenberg, and King 2000) to explore our results in greater detail. Our general approach is to explore the marginal effect of the various factors individually while holding the other covariates constant at their observed sample means or, for dichotomous variables, the modal values as reported in Table 1.

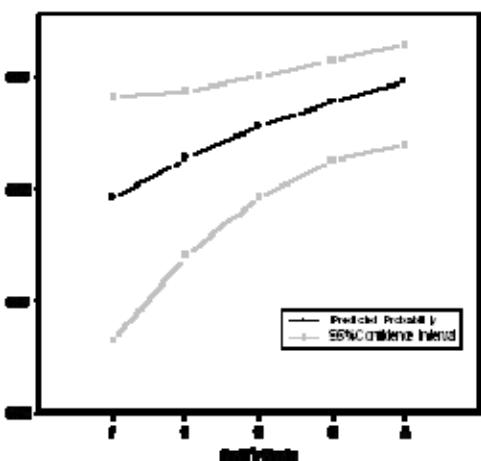


Figure 1: Predicted probabilities (and 95% confidence intervals) of deciding to remain at present school for increasing levels of school facility quality, holding all other covariates constant at their mean or modal values.

In Figure 1, we present predicted probabilities of an average teacher deciding to remain at her present school across increasing levels of perceived facilities quality. As the figure shows, the mean predicted probabilities increase over the range of grades, but at a slightly decreasing rate. The maximum difference between predicted probabilities is about .05-this represents the predicted average increase in probability of a teacher deciding to stay at her job were she moved from a school with the lowest facility quality to one with the highest and all other factors held constant.

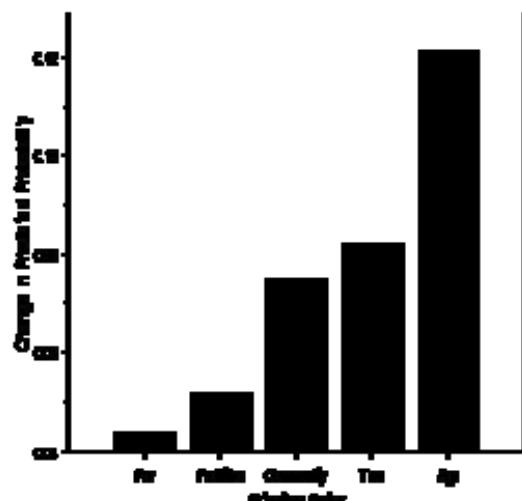


Figure 2: Comparison of the marginal effects of the various statistically significant factors on the predicted probability of the decision to remain at the present school.

As Figure 2 shows, the effect of facilities quality, while small in comparison to the effect of being middle-aged versus very young and the other two factors, is nevertheless larger than the effect of dissatisfaction with pay ($p < .05$). While this comparison is based on the change of a school's facility quality from F to A, even a change in perceived quality from F to only C yields an increase in predicted probability of retention of .03-almost two-thirds of the pay effect. In short, the effect of facilities quality on retention is substantively significant.

Discussion

Schools and school districts attempting to increase their rate of teacher retention have several possible strategies, some more feasible than others. The results of our empirical analysis suggest that the most important factors-age and time in service at the school-are largely not under the control of administrators.

Of the remaining significant factors, pay, parent and community involvement, and facilities quality, the one with the largest effect is improving the teachers' relationship with parents and the broader community. Strategies to accomplish exactly this have been a staple of education reform for decades, but progress is difficult and the challenge of increasing parental involvement is perhaps greatest in urban districts such as Washington, D.C., the school system we study in this research. Increasing teacher salaries appears to improve retention, but this is also a difficult task in a time of

reduced budgets and personnel are the single largest expense in the provision of education.

Improving the quality of school facilities can be expensive as well. However, as our research here suggests, the benefits of facility improvement for retention can be equal to or even greater than those from pay increases. Furthermore, a major facilities improvement is likely to be a one-time expense, last for many years, and have supplemental sources of state or federal funding available. It could thus be more cost-effective teacher retention strategy than a permanent salary increase for teachers in the medium- to long-term. Indeed, in the limited research on facilities and retention in developing nations, facilities improvement has been found to offset low wages (MacDonald 1999; Oliveira and Farrell 1993). Our research suggests the same may be true in the United States as well.

References

American Speech-Language-Hearing Association. 1995. Guidelines for acoustics in educational environments. American Speech-Language-Hearing Association, 37, Suppl.14, pp.15-19.

Antos, Joseph R., and Sherwin Rosen. 1975. "Discrimination in the market for teachers." *Journal of Econometrics* 2 (May):123-150.

Baugh, William H., and Joe A. Stone. 1982. "Mobility and wage equilibration in the educator labor market." *Economics of Education Review* 2, no.3 (Summer):253-274.

Benner, A. D. 2000. "The Cost of Teacher Turnover." Austin, Texas: Texas Center for Educational Research. Retrieved April 23, 2002, from http://www.sbec.state.tx.us/SBECOnline/txbess/turnover_rpt.pdf

Benya, J. R. 2001. "Lighting for Schools." Washington, D.C.: National Clearinghouse for Educational Facilities. Retrieved 07/03/02 from <http://www.edfacilities.org/pubs/lighting.html>

Cash, C. S. 1993. *A study of the relationship between school building condition and student achievement and behavior*. Blacksburg, Va.: Virginia Polytechnic Institute and State University.

Chambers, Jay G. 1977. "The impact of collective bargaining for teachers on resource allocation in public school districts." *Journal of Urban Economics* 4,no.3 (July):324-339.

Chapman, D.W. 1994. *Reducing Teacher Absenteeism and Attrition: Cause, Consequences, and Responses*. Paris: UNESCO, Institute for Education Planning.

Corcoran, T. B., L. J. Walker and J. L. White. 1988. *Working in urban schools*. Washington D.C.: Institute for Educational Leadership. (ED299356)

Crandell, C. 1991. "Classroom Acoustics for Normal-hearing Children: Implications for Rehabilitation." *Educational Audiology Monographs* 2(l):18-38.

Crandell, C., J. Smaldino, and C. Flexer. 1995. *Sound field FM amplification: theory and practical applications*. Los Angeles, Calif.: Singular Press.

Crandell, C., and F. Bess. 1986. *Speech recognition of children in a 'typical' classroom setting*. American Speech-Language-Hearing Association, 29, pp. 87-98.

Darling-Hammond, Linda, Gary Sykes. 2003. *Wanted: A National Manpower Policy for Education*. Denver, Colorado: Education Commission of the States.

Dolton, P. and van der Klaauw, W. 1995. "Leaving Teaching in the UK: A Duration Analysis." *The Economic Journal* 105, 431-444.

Earthman, G. I. and L. Lemasters. 1996. "Review of research on the relationship between school buildings, student achievement, and student behavior." Paper presented at the annual meeting of the Council of Educational Facility Planners International. Tarpon Springs, Fla., October 1996.(ED416666)

Education Law Center. 2002. "Abbott School Facilities.", Retrieved December 2, 2003 <http://www.edlawcenter.org/ELCPublic/AbbottSchoolFacilities/AbbottSchoolConstructionProgram.htm>

Environmental Protection Agency. 2000. *Indoor air quality and student performance*. EPA Report number EPA 402-F-00-009. Washington, D.C.: Author. Retrieved 06/10/02 from http://www.epa.gov/iaq/schools/images/iaq_and_student_performance.pdf

Evans, G. W. and L. Maxwell. 1999. "Chronic Noise Exposure and Reading Deficits: the Mediating Effects of Language Acquisition." *Environment and Behavior* 29(5): 638-656.

Figlio, D. 2001. *What Might School Accountability Do?* Cambridge, Mass.: National Bureau of Economic Research.

General Accounting Office. 1995. *School facilities: America's schools not designed or equipped for 21st century.* (GAO Report number HEHS-95-95). Washington, D.C.: Author. (ED383056)

Gritz, R.M., N.D. Theobold. 1996. "The Effects of School District Spending Priorities on Length of Stay in Teaching." *Journal of Human Resources* 31(3):477-512.

Hargreaves, A. 1994. *Changing Teachers, Changing Times*. London: Cassell.

Hanushek, Eric A., Kain, John F., and Alice Rivkin, forthcoming. "Why Public Schools Lose Teachers." *Journal of Human Resources*.

Hanushek, Eric A., and J. A. Luque. 2000. "Smaller classes, lower salaries? The effects of class size on teacher labor markets." In *Using what we know: A review of the research on implementing class-size reduction initiatives for state and local policymakers*, edited by Sabrina W.M. Laine and James G. Ward. Oak Brook, IL.: North Central Regional Educational Laboratory:35-51.

Harris, Steven A., William E. Camp, and Judith Adkison. 2003. "New Structures and Approaches for Teacher Preparation: Do They Make a Difference in Teacher Retention?" Paper presented at the Annual Meeting of the American Association of Colleges for Teacher Education, New Orleans, LA., January 24-27.

Heschong Mahone Group. 1999. *Daylighting in schools: an investigation into the relationship between daylighting and human performance*. Fair Oaks, Calif.: Author. Retrieved 07/03/02 from http://www.pge.com/003_save_energy/003c_edu_train/ec/daylight/di_pubs/SchoolDetailed820App.PDF

Ingersoll, R. 2000. "Turnover Among Mathematics and Science Teachers in the U.S." Paper prepared for the National Commission on Mathematics and Science Teaching for the 21st Century, Chaired by John Glenn. Retrieved from <http://www.ed.gov/initis/Math/glenn/compapers.html>

Jago, E., and K. Tanner. 1999. *Influence of the school facility on student achievement: lighting; color*. Athens, Ga.: Dept. of Educational Leadership; University of Georgia. Retrieved 07/22/02 from <http://www.coe.uga.edu/sdpl/researchabstracts/visual.html>

Jones, T. 2001. "An Initial Exploration into a Time of Change: Teacher Perception of Their Profession in the New Millennium." Paper presented in the SPERA National Conference (17th, Wagga Wagga, New South Wales, Australia, July 8-11, 2001).

Kemmerer, F. 1990. "A Integrated Approach to Primary Teacher Incentives." Pp. 136-152 *Improving Educational Quality: A Global Perspective*, edited by D.W. Chapman and C.A. Carrier. London: Greenwood Press.

Kennedy, M. 2001. "Into Thin Air." *American School & University* 73(6): 32.

King, G., M. Tomz and J. Wittenberg. 2000. "Making the Most of Statistical Analyses: Improving Interpretation and Presentation." *American Journal of Political Science* 44(2):347-61.

Lackney, J. A. 1999. "Assessing school facilities for learning/assessing the impact of the physical environment on the educational process." Mississippi State, Miss.: Educational Design Institute. September 17, 1999. (ED441330)

Leach, K. 1997. "In Sync with Nature: Designing a Building with Improved Indoor Air Quality Could Pay off with Improved Student Health and Performance." *School Planning and Management*, 36(4):32-37.

Lemasters, L. K. 1997. "A synthesis of studies pertaining to facilities, student achievement, and student behavior." Blacksburg, Va.: Virginia Polytechnic and State University. (ED447687)

Liang, K.-L., S.L. Zeger. 1986. "Longitudinal Data Analysis Using Generalized Linear Models." *Biometrika* 73:13-22.

Liao, T.F. 1994. "Interpreting Probability Models: Logit, Probit, and other Generalized Models.":87.

Lowe, J. M. 1990. *The interface between educational facilities and learning climate in three elementary schools*. Unpublished diss. College Station, Tex.: Texas A&M University.

Lucas, J. 1981. *Effects of noise on academic achievement and classroom behavior*. Sacramento, Calif.: California Department of Health Services.

MacDonald, D. 1999. "Teacher Attrition: A Review of Literature." *Teaching and Teacher Education* 15:839-848.

Macdonald, D. 1995. "The Role of Proletarianization in Physical Education Teacher Attrition." *Research Quarterly for Exercise and Sport* 66(2):129-141.

Miech, R. and G. H. Elder, Jr. 1996. "The Service Ethic and Teaching." *Sociology of Education* 69: 237-253.

Murnane, R. J., and R. Olsen. 1989. "The effects of salaries and opportunity costs on length of stay in teaching: Evidence from Michigan." *Review of Economics and Statistics* 71,no.2 (May):347-352.

---. 1990. "The effects of salaries and opportunity costs on length of stay in teaching: Evidence from North Carolina." *Journal of Human Resources* 25,no.1 (Winter):106-124.

Nabelek, A. and L. Nabelek. 1994. "Room Acoustics and Speech Perception." In *Handbook of Clinical Audiology*, 3rd Edition, ed., J. Katz. Baltimore, Md.: Williams and Wilkins.

Northeast and Islands Regional Educational Laboratory at Brown University. 1997. *School Facilities: Declining Conditions, Declining Opportunities*. Providence, R.I.: Brown University.

Oliveira, J. and J. Farrell. 1993. "Teacher Costs and Teacher Effectiveness in Developing Countries." Pp. 7-24 *Teachers in Developing Countries: Improving Effectiveness and Managing Costs*, edited by J. Oliveira and J. Farrell. Washington, D.C.: World Bank.

Phillips, R. 1997. *Educational facility age and the academic achievement of upper elementary school students*. D. Ed. diss., University of Georgia.

Plympton, P., S. Conway, and K. Epstein. 2000. "Daylighting in Schools: Improving Student Performance and Health at a Price Schools Can Afford." Paper presented at the American Solar Energy Society Conference, Madison, Wisconsin, June 16, 2000. Retrieved 07/22/02 from:
http://www.deptplanetearth.com/nrel_student_performance.htm

Rogers, W.H. 1993. "sg17: Regression Standard Errors in Clustered Samples." *Stata Technical Bulletin* 53:32-35.

Rosen, K. G., and G. Richardson. 1999. "Would Removing Indoor Air Particulates in Children's Environments Reduce Rate of Absenteeism - a Hypothesis." *The Science of the Total Environment*, 234 (3): 87-93.

Rosenhotz, S.J., and C. Simpson. 1990. "Workplace conditions and the rise and fall of teachers' commitment." *Sociology of Education*, 63, 241 - 247.

Rowan, B., R. Correnti, and R. J. Richard. 2002. "What Large-Scale Survey Research Tells Us about Teacher Effects on Student Achievement." Philadelphia, Penn.: Consortium for Policy Research in Education, University of Pennsylvania. Retrieved April 23, 2002, from
<http://www.cpre.org/Publications/r51.pdf>

Schneider, M. 2002. "School Facilities and Academic Outcomes." National Clearinghouse for Educational Facilities. Washington DC. 2002.
<http://www.edfacilities.org/pubs/outcomes.pdf>.

Schneider, M. 2003. "Linking School Facility Conditions to Teacher Satisfaction and Success." National Clearinghouse for Educational Facilities. Washington DC.2003.
<http://www.edfacilities.org/pubs/teachersurvey.pdf>

Smedje, G., and D. Norback. 1999. "The School Environment: Is It Related to the Incidence of Asthma in the Pupils?" In *Indoor Air '99*. The Eighth International Conference on Indoor Air Quality and Climate. vol.5. pp.445-450.

Stinebrickner, T.R. 2001. "A Dynamic Model of Teacher Labor Supply.: *Journal of Labor Economics* 19 (1): 196-230.

Tapper, D. 1995. *Swimming Upstream: The First-Year Experience of Teachers Working in New York City Public Schools*. Educational Priorities Panel, New York.

Tomz, M., J. Wittenberg and G. King. 2000. "CLARIFY: Software for Interpreting and Presenting Statistical Results." Cambridge, Mass.: .

Tye, B. B., L. O'Brien. 2002. "Why Are Experienced Teachers Leaving the Profession?" *Phi Delta Kappan* 84(1):24-32.

White, H. 1980. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica* 48:817-830.

i There is a large literature linking facility quality to educational outcomes. See for example, Cash (1993), Earthman and Lemasters (1996), Lemasters (1997), Lackney (1999), and Schneider (2002).

ii In the next few paragraphs we supplement our review of the literature linking facilities to outcomes with examples from Washington DC. The data upon which these examples are drawn and which we use more extensively later in the paper, are from a pencil-and-paper survey of all teachers in Washington, D.C. administered in May-June of 2002. Approximately 25% of teachers in the District returned the survey, which was distributed and collected by building representatives of the Washington Teachers Union.

iii In a study of Chicago teachers that paralleled the DC survey, over one-quarter of Chicago teachers reported asthma and respiratory problems as the most frequent health problems they encountered. Another 16 % reported other problems (such as sinus infections) that may also be linked to poor IAQ.

iv Recall that the response rate was about 25%. Although this is rather low, it nevertheless represents an improvement over much of the empirical literature on retention. For example, Tye and O'Brien (2002) only attain a response rate of 12.6% to their mail survey. The key issue, of course, is whether-or-not the self-selection to respond biases our results in any way (e.g. if only the most disgruntled teachers respond). Even if this is true, however, this self-selected sample may actually been exactly those teachers most likely to respond to changes in the various factors discussed below.

v The number of teachers responding to the survey from a given school ranges from 1 to 34, with an average of about 13. As a sensitivity test of our model, we also estimated a generalized estimating equations (Liang and Zeger 1986) model assuming that the teachers are exchangeable within schools. These results are substantively similar to those reported below.

vi Note that the positive coefficient on age but the negative coefficient on the square of age supports the general conclusion of the teacher retention literature that, "most of those who leave teaching in any given year are either disillusioned beginners with just two or three years in the classroom or 30-year veterans who are ready to retire." (Tye and O'Brien 2002: 24).

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